June 22, 1971 C. WILKINS 3,586,584

AUTOMATIC PLASTIC WELDING MACHINE

Filed Oct. 28, 1968 5 Sheets-Sheet 1

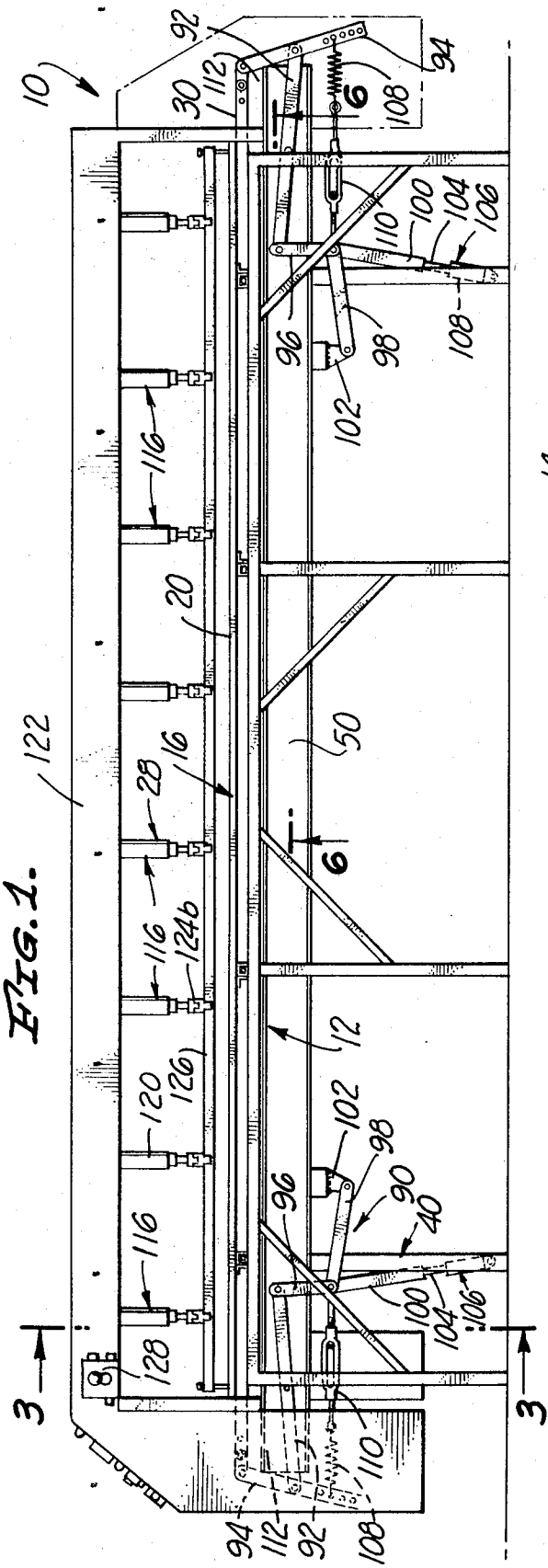


FIG. 1.

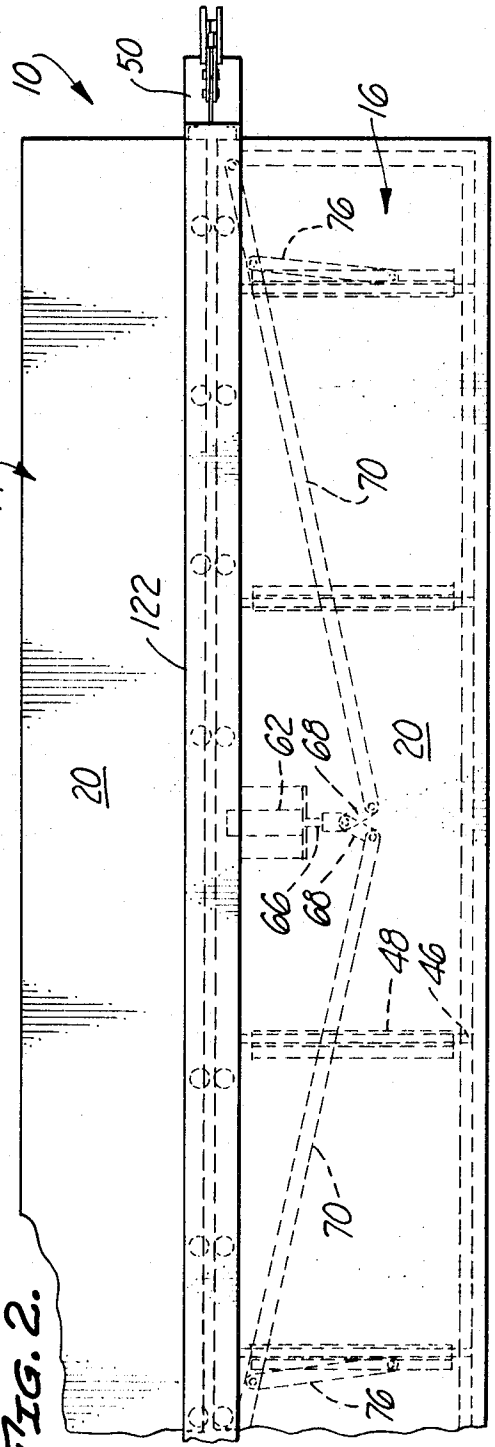


FIG. 2.

INVENTOR
CHESTER WILKINS

BY
Bernard L. Brown
ATTORNEY

AUTOMATIC PLASTIC WELDING MACHINE

Filed Oct. 28, 1968 5 Sheets-Sheet 2

FIG. 3.

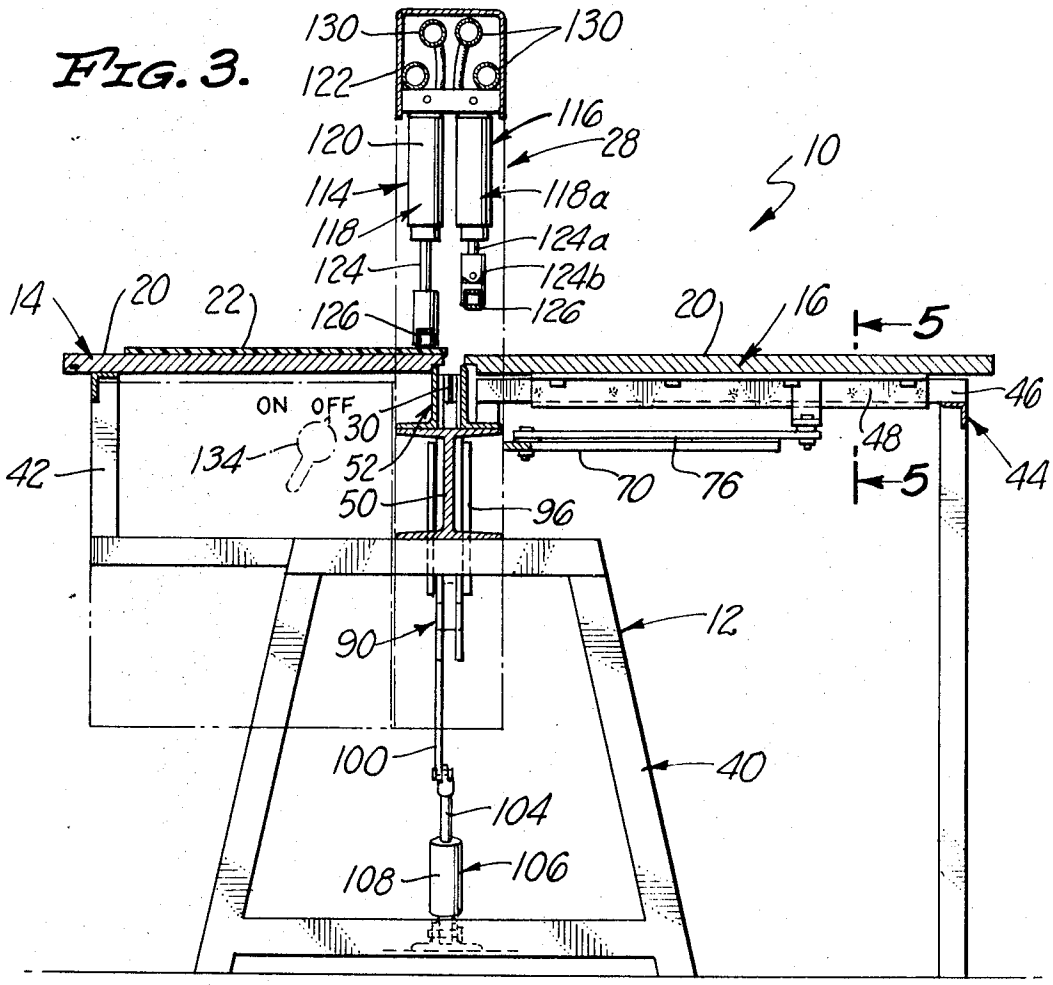


FIG. 4.

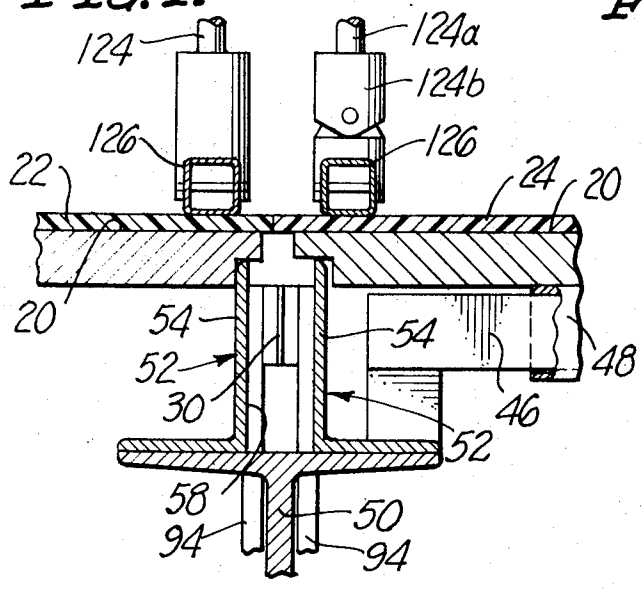
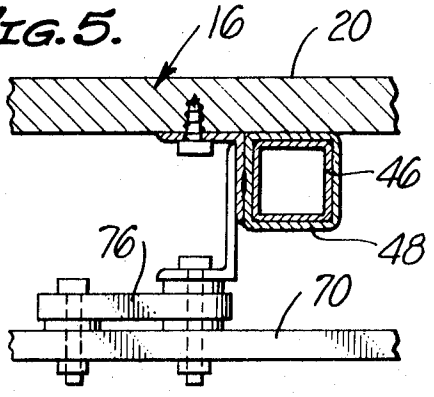


FIG. 5.



INVENTOR
CHESTER WILKINS

BY
Bernard A. Brown
ATTORNEY

June 22, 1971 C. WILKINS 3,586,584

AUTOMATIC PLASTIC WELDING MACHINE

Filed Oct. 28, 1968 5 Sheets-Sheet 3

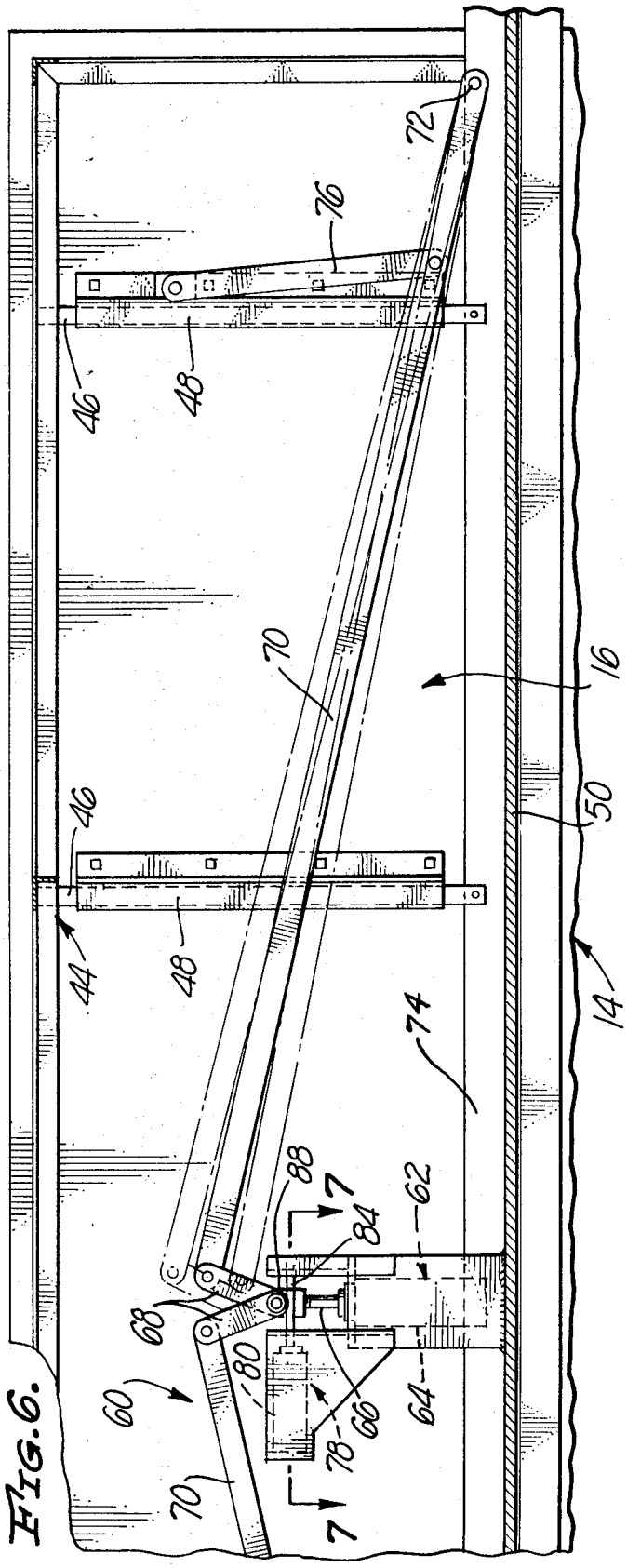


FIG. 6.

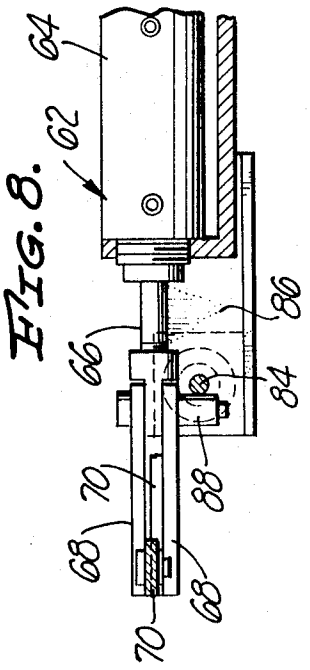


FIG. 8.

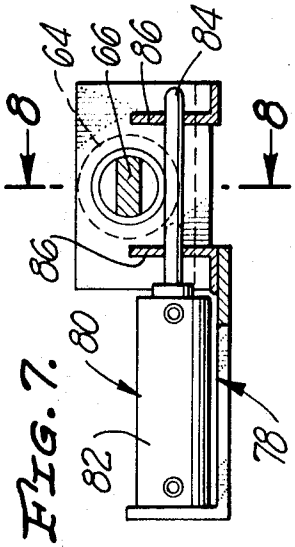


FIG. 7.

INVENTOR
CHESTER WILKINS

BY
Bernard A. Brown
ATTORNEY

AUTOMATIC PLASTIC WELDING MACHINE

Filed Oct. 28, 1968 5 Sheets-Sheet 4

FIG. 9.

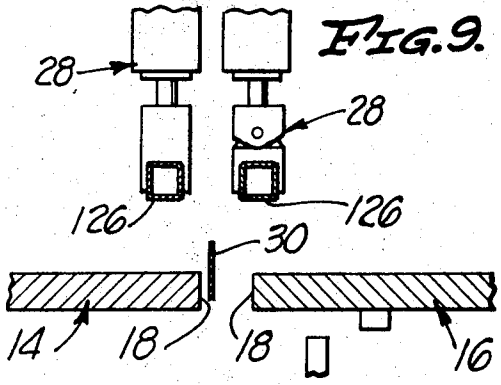


FIG. 10.

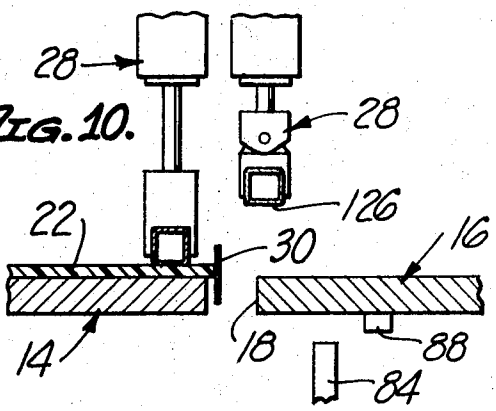


FIG. 11.

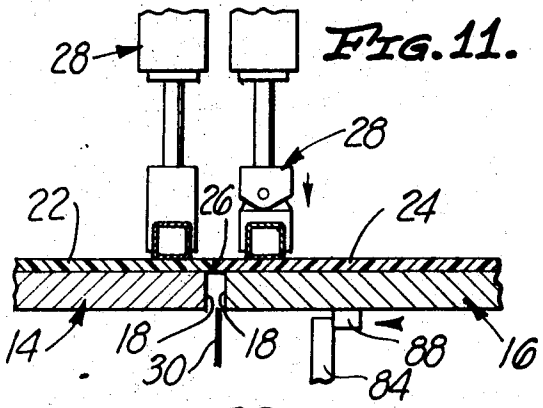


FIG. 12.

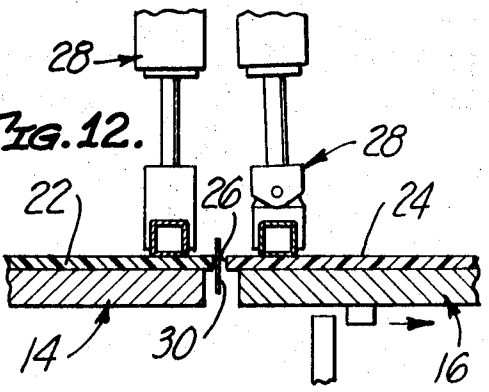


FIG. 13.

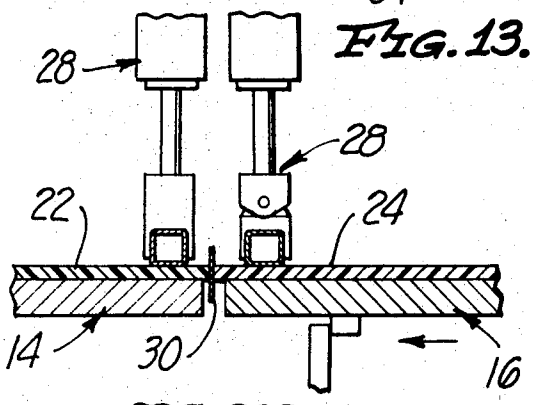


FIG. 14.

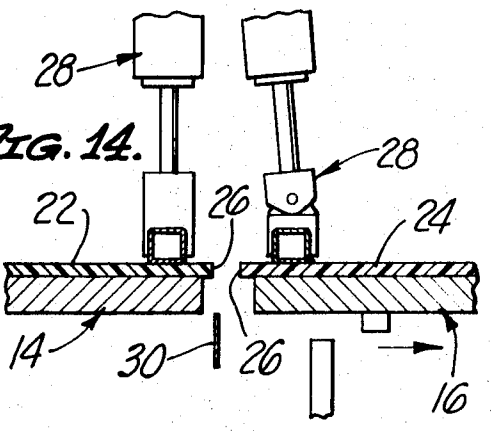
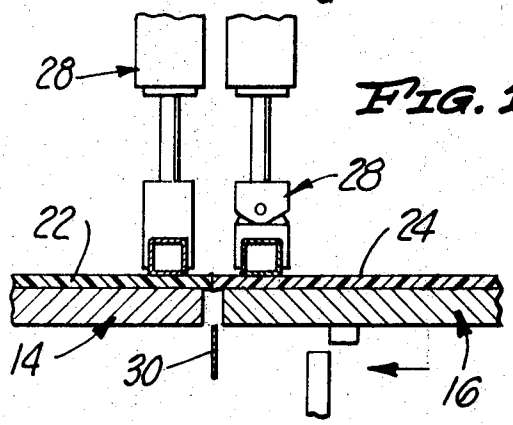


FIG. 15.



INVENTOR
CHESTER WILKINS

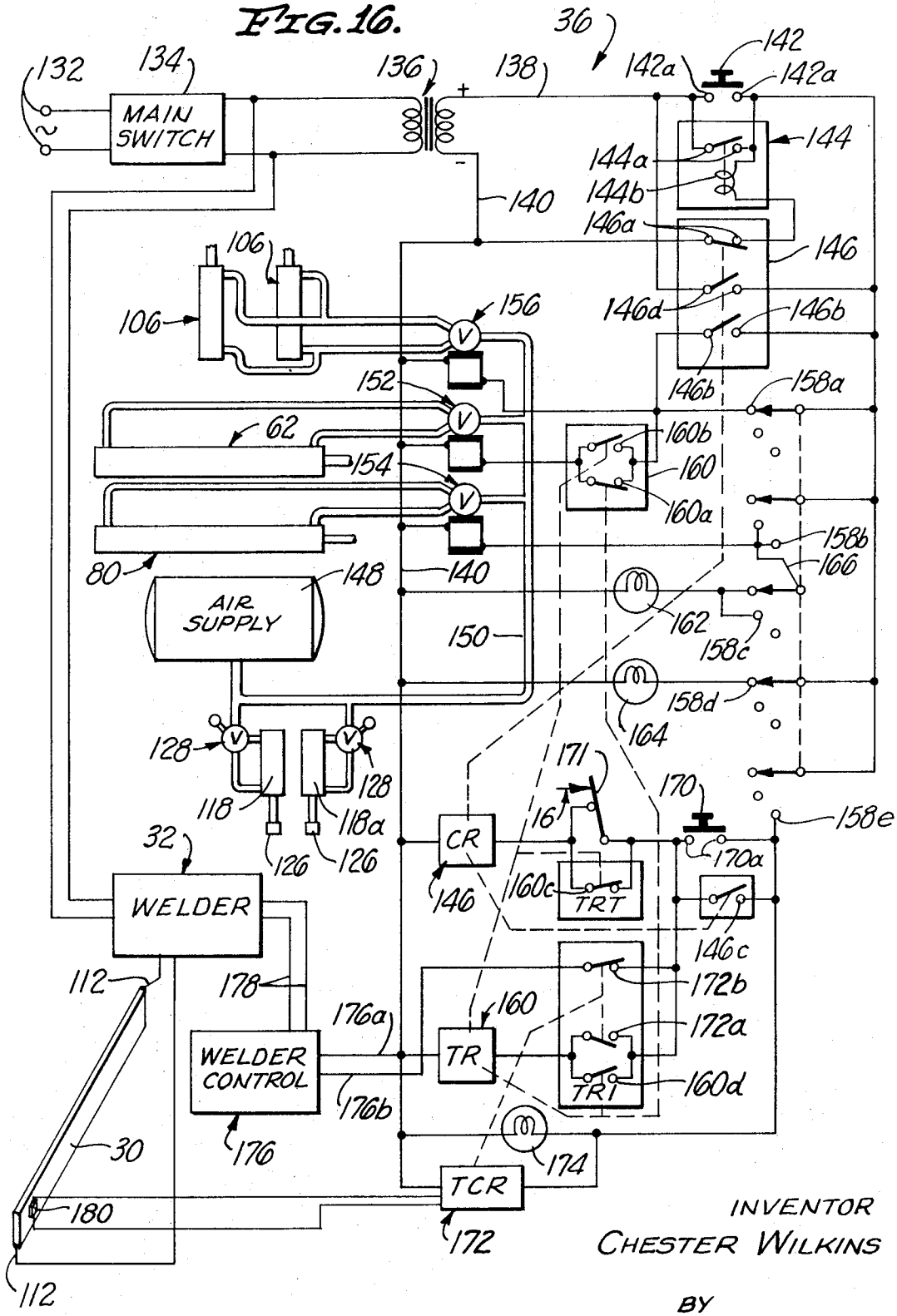
BY

Bernard L. Brown
ATTORNEY

AUTOMATIC PLASTIC WELDING MACHINE

Filed Oct. 28, 1968 5 Sheets-Sheet 5

FIG. 16.



INVENTOR
CHESTER WILKINS

BY

Bernard L. Brown

ATTORNEY

United States Patent Office 3,586,584 Patented June 22, 1971

3,586,584

AUTOMATIC PLASTIC WELDING MACHINE

Chester Wilkins, 741 W. La Denny Drive, Ontario, Calif. 91764

Filed Oct. 28, 1968, Ser. No. 770,969
Int. Cl. B29c 27/02
U.S. Cl. 156—499 7 Claims

ABSTRACT OF THE DISCLOSURE

An automatic machine is provided for formally butt welding to thermoplastic work members, such as plastic sheets. The machine has a frame mounting relatively movable horizontal work tables to which are clamped the work members to be joined, a heater blade which moves vertically between the tables, and an automatic control system which is operable to cause the machine to proceed through an automatic work cycle involving initial retraction of the work tables to separate the work members, heating of the blade to a predetermined temperature, movement of the heated blade to an extended position between the work members, inward extension of the work tables toward one another to engage the confronting edge surfaces of the work members with opposite sides of the blade, whereby these edge surfaces are heated to a tacky state, momentary retraction of the work tables to separate the work members, retraction of the heater blade from between the work members, and final inward extension of the work tables to press the tacky surfaces of the work members firmly together for a period of time sufficient to enable firm bonding of the members to one another.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to plastic working machines. More particularly, the invention relates to a novel automatic machine for formally butt welding to thermoplastic work members, such as plastic sheets, to one another edge to edge.

Prior art

Various techniques have been devised for joining edge to edge plastic work members, such as plastic sheets. Two of the more common techniques are adhesive bonding and thermal welding. The present invention is concerned with this latter technique and will be disclosed in connection with thermally butt welding two plastic sheets to one another.

There is currently available on the market a thermoplastic butt welding machine for joining two plastic sheets in this fashion. Briefly, this machine comprises a frame mounting two relatively movable horizontal work tables. These are provided for clamping the plastic work members or sheets to be joined to these work tables along the confronting edges of the tables. Movable vertically between the tables is a heater blade. During a typical work cycle of such a machine, the blade is initially heated to a predetermined temperature and extended to a work heating position, wherein the blade is situated between the confronting edge surfaces of the work members which are clamped to the work tables. The work tables are then driven in relative edgewise movement to effect relative extension of the tables toward one another to bring the edge surfaces of the work members into contact with

opposite sides of the hot blade. These edge surfaces are thereby heated to a tacky state by the blade. At this point, the tables are momentarily retracted away from one another to permit retraction of the heater blade from between the work members, after which the tables are again extended inwardly toward one another to bring the tacky edge surfaces of the work members into firm bonding contact. The work members are retained in this bonding relation for a period of time sufficient to enable cooling of the surfaces and, thereby, secure thermal bonding of the work members to one another.

SUMMARY OF THE INVENTION

The present invention provides an improved thermoplastic butt welding machine of the character described which is automatic in operation. Generally speaking, this machine comprises the same basic structure as the existing plastic welding machines just described. Thus, the present machine comprises a frame, relatively movable work tables on the frame, means for clamping the work members to be joined to the work tables along the confronting edges of the tables, a heater blade movable vertically between the tables, means for heating the blade, means for driving the work tables in relative edgewise movement toward and away from one another, and means for driving the heater blade vertically between extended and retracted positions relative to the tables. As will appear presently, however, the present machine does embody certain novel mechanical features which particularly adapt the machine for its automatic operation. The primary contribution of the present invention resides in an automatic control system for causing the machine to proceed through an automatic work cycle. This work cycle involves initial relative retraction of the work tables to separate the plastic work members which are clamped to the work tables, heating of the heater blade to a predetermined temperature and extension of the blade to a work heating position between the confronting edge surfaces of the work members, relative inward extension of the work tables to bring the edge surfaces of the work members into contact with opposite sides of the heated blade for a period of time sufficient to heat these surfaces to a tacky state, momentary retraction of the tables to separate the work members, retraction of the heater blade from between the work members, and final reextension of the work tables toward one another to bring the tacky edge surfaces of the work members into firm bonding engagement. The work members are retained in this bonding relation sufficiently long to enable the contacting surfaces to cool or set.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of an automatic plastic welding machine according to the invention;

FIG. 2 is a fragmentary top plan view of the machine;

FIG. 3 is an enlarged section taken on line 3—3 in FIG. 1 showing the work tables of the machine separated or retracted and a plastic work sheet clamped to one of the tables;

FIG. 4 is an enlarged fragmentary vertical section through the machine showing a pair of plastic work sheets clamped to the work tables with the latter extended to bring the confronting edge surfaces of the sheets into firm bonding engagement;

FIG. 5 is a section taken on line 5—5 in FIG. 3;

FIG. 6 is an enlarged section taken on line 6—6 in FIG. 1;

FIG. 7 is an enlarged section taken on line 7—7 in FIG. 6;

FIG. 8 is a section taken on line 8—8 in FIG. 7;

FIGS. 9 through 15 diagrammatically illustrate the automatic working cycle of the machine; and

FIG. 16 schematically illustrates the automatic control system of the machine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to these drawings, there is illustrated an automatic plastic welding machine **10** according to the invention. This machine has a frame **12** mounting a pair of work tables **14** and **16**. Tables **14** and **16** are located in a common horizontal plane and have confronting parallel edges **18** and upper work supporting surfaces **20**. The tables are supported on the frame for relative edgewise movement toward and away from one another. In the particular welding machine illustrated, the left-hand work table **14** is rigidly fixed to the frame. The right-hand work table **16** is supported on the frame for edgewise movement toward and away from the fixed table **14**.

Work tables **14** and **16** are adapted to support a pair of thermoplastic work members **22** and **24** to be thermally butt welded to one another. In this case, the work members comprise thermoplastic sheets which are placed on the upper work supporting surfaces **20** of the work tables with edge surfaces **26** of the sheets confronting one another and disposed in parallel relation to the confronting edges **18** of the tables. As shown best in FIGS. 4 and 9 through 15, these inner confronting edges of the work sheets project inwardly a small distance beyond the inner confronting edges of the tables. Clamping means **28** are provided for releasably clamping the work members or work sheets **22**, **24** to the work tables **14**, **16** along the inner edges **18** of the tables.

Mounted on the machine frame **12**, in a vertical plane passing between and parallel to the inner confronting edges **18** of the work tables **14**, **16** is a heater blade **30**. This blade is movable vertically in its plane to and from a position between the confronting inner edge surfaces **26** of the work sheets **22**, **24**. Associated with the blade **30** are means **32** for heating the blade.

The plastic welding machine **10**, as it is thus far described, is generally conventional. A primary feature of the invention resides in a control system **36** (FIG. 16) for the machine. This control system has manual set-up and automatic operating modes. During the manual set-up mode of the control system, the machine is properly conditioned for its automatic operating mode. During this automatic operating mode, the machine proceeds through an automatic welding cycle to thermally butt weld the plastic sheets **22**, **24** to one another.

The operation of the present plastic welding machine **10** will now be briefly described by reference to FIGS. 9 through 15. It should be noted here that FIGS. 9 through 11 depict the automatic set-up mode of the machine, and FIGS. 12 through 15 depict the automatic operating or welding mode of the machine.

In the normal inoperative condition of the present plastic welding machine **10**, the work tables **14**, **16**, work clamping means **28**, and heater blade **30** occupy the positions of FIG. 9. In these positions, the work tables are retracted outwardly away from one another, the work clamping means **28** are retracted upwardly away from the tables, and the heater blade **30** is extended to a work heating position, wherein the blade is situated approximately at the level of the upper work supporting surfaces **20** of the tables. The blade is then disposed between and generally parallel to the inner confronting edges **18** of the tables.

Referring to FIG. 10, the initial step in the manual set-up mode of the machine involves placement of one plastic work member or sheet **22** on the fixed left-hand work table **14**. The sheet is then moved edgewise toward

and into contact with the adjacent side of the heater blade **30**, as shown. At this point, the work clamping means **28** are operated to clamp the work sheet **22** to the work table **14**, along the inner edge **18** of the table. The right-hand work table **16** is then extended inwardly toward the fixed work table **14** to the position illustrated in FIG. 11. In the ensuing description, the relative positions of the work tables illustrated in FIGS. 9 and 10 and in FIG. 11 are referred to, respectively, as their retracted positions and their extended work bonding positions.

Following inward extension of the movable work table **16** to its position of FIG. 11 and the dropping of blade **30**, the work member or sheet **24** is positioned on the table and is moved edgewise toward the work sheet **22** to a position wherein the inner confronting edge surfaces **26** of the two sheets abut one another, as shown. The work clamping means **28** are then operated to clamp the work sheet **24** to the work table **16** along the inner edge **18** of the table. The plastic welding machine **10** is then conditioned for its automatic work cycle.

During the initial phase of this automatic cycle, the movable work table **16** is retracted outwardly to separate the work sheets **22**, **24**, and the heater blade **30** is extended upwardly to its work heating position of FIG. 12, wherein the blade is disposed between the confronting edge surfaces **26** of the work sheets. Generally concurrently, the blade heating means **32** are activated to heat the blade to a predetermined temperature, on the order of 600° F. When this blade temperature is attained, the right-hand work table **16** is again extended inwardly to its position of FIG. 13. In this position, the inner edge surface **26** of the work sheet **24** presses against the adjacent side of the heated blade **30** and thrusts the blade firmly against the inner edge surface **26** of the work sheet **22**. Under these conditions, the inner edge surfaces **26** of the work sheets **22**, **24** are pressed into firm contact with and are thereby heated by the balde. The work sheets are retained in this heating position sufficiently long to effect heating of their inner edge surfaces to a tacky state. In the ensuing description, the work table and heater blade positions illustrated in FIG. 13, wherein heating of the inner sheet edges **26** is accomplished, are referred to as the extended work heating position of the blade and the intermediate work heating position of the work tables, respectively. As will appear presently, the work clamping means **28** are uniquely constructed to accommodate outward retraction and inward extension of the movable work table **16**, in the manner just explained.

After the inner edge surfaces **26** of the work sheets **22**, **24** have been heated, by the heater blade **30**, to the proper tacky state, the movable work table **16** is again retracted outwardly to separate the work sheets, as illustrated in FIG. 14. The heater blade **30** is then retracted downwardly from between the work sheets. Immediately after retraction of the blade, the work table **16** is extended inwardly to its corresponding position of FIG. 15 to bring the confronting, now tacky edge surfaces **26** of the work sheets **22**, **24** into firm bonding engagement, as illustrated in FIG. 15. The work sheets are retained in bonding engagement for a period of time sufficient to enable cooling or setting of their contacting surfaces. The work clamping means **28** are then retracted and the now butt welded work sheets **22**, **24** are removed from the machine to complete one operating cycle of the machine.

Referring now in greater detail to the embodiment of the invention which has been selected for illustration in the drawings, the machine frame **12** may be provided with any convenient shape and, in this instance, has a base **40** to which the left-hand table **14** is rigidly attached by means of frame members **42**. The machine frame **12** also includes a horizontal frame platform **44** located directly below the movable work table **16**. This platform has spaced parallel frame bars **46** which extend horizontally across the underside of the work table **16**, normal to its inner edge **18**. Bolted to the underside of the work table **16** are

a number of bearing sleeves **48**. These bearing sleeves are equal in number to and slidably receive the frame bars **46**. The work table bearing sleeves **48** are somewhat shorter than the frame bars **46**, as may be best observed in FIG. 6. The bars and sleeves serve to support the movable work table **16** on the machine frame **12** for edgewise movement of the table between its extended and retracted positions relative to the fixed work table **14**.

Extending across the top of the frame base **40**, directly below and parallel to the inner confronting edges **18** of the work tables **14, 16**, is a beam **50**. This beam is rigidly attached to the frame base. Welded or otherwise rigidly joined to the upper flange of the beam **50** are a pair of angles **52** having upstanding vertical flanges **54**. The inner edge of the fixed work table **14** rests on and is rigidly secured to the flange **54** of the left-hand frame angle **52**, in FIG. 4. The inner edge of the movable work table **16** overlies and is disposed in slidable vertical supporting engagement with the vertical flange **54** of the right—and frame angle **52** in FIG. 4. In FIG. 4, it will also be observed that the inner ends of the work table supporting frame bars **46** are supported on and rigidly attached to the frame beam **50**.

As shown best in FIG. 4, the upstanding frame angle flanges **54** are spaced to define therebetween an elongate upwardly opening channel **58** directly below the inner confronting edges **18** of the work tables **14, 16**. The heater blade **30** extends longitudinally through this channel and is mounted on the machine frame **12** for vertical movement in the channel, as will be hereinafter explained.

Associated with the movable work table **16** are table drive means **60** for moving the table between its extended and retracted positions and through its intermediate work bonding position. Referring to FIG. 6, the table drive means **60** comprise a fluid pressure operated ram **62** having a cylinder **64** rigidly mounted on the frame platform **44**. The cylinder **64** is located intermediate the ends of the platform and is disposed with its axis horizontal and extending parallel to the direction of edgewise movement of the work table **16**. Movable within the cylinder **64** is a plunger **66** which extends from the inner end of the cylinder, as shown. A pair of connecting links **68** are pivotally attached at one end to the outer end of the ram plunger **66**. Pivotally attached to the outer ends of the connecting links **68**, respectively, are a pair of work table operating levers **70**. Each lever **70** extends generally lengthwise of the machine frame **12** and from its respective connecting link **68** toward the adjacent end of the frame. The distal end of each table operating lever **70** is pivotally attached at **72** to the adjacent end of flange **74** of beam **50** of the frame platform **44** which extends along the outer edge of the platform. Pivotally connected between the outer end of each work table operating lever **70** and the adjacent end of the movable work table **16** is a connecting like **76**.

It is evident from the above description and from FIG. 6 that extension and retraction of the ram plunger **66** is effective to drive the movable work table **16** edgewise toward and away from the fixed work table **14**. More specifically, upward or inward extension of the ram plunger **66** in FIG. 6 drives the work table **16** inwardly to its extended work bonding position shown in FIGS. 4, 11 and 15. Downward or outward retraction of the plunger in FIG. 6 drives the work table **16** to its outer retracted position shown in FIGS. 9 and 10.

Also associated with the movable work table **16** are means **78** for effecting inward extension of the table to its intermediate work heating position of FIG. 13. In this case, the means **78** comprise a limit stop means including a fluid pressure actuated ram **80** having a ram cylinder **82**. The axis of the ram cylinder **82** extends normal to and is laterally displaced from the axis of the ram cylinder **64**. Movable within the ram cylinder **82** is a plunger **84** which acts as and will be hereinafter referred

to as a stop. Stop **84** extends slidably through a pair of aligned bearing holes which are drilled through plates **86** rigid on the table operating ram **62**. Referring to FIG. 7, it will be observed that these plates are located at opposite sides of the table operating ram plunger **66**. Stop **84** is movable longitudinally between its solid line extended position and its broken line retracted position of FIG. 7. In its extended position, the stop is situated within the path of a laterally projecting lug **88** on the ram plunger **66**. When retracted, the stop clears the lug.

The work table drive means **60** are so constructed and arranged that outward or downward retraction of the work table operating ram plunger **66** in its cylinder **64** in FIG. 6 drives the movable work table **16** outwardly to its retracted position of FIGS. 9 and 10. Upward or inward extension of the ram plunger **66** from this retracted position, with the work table stop **84** extended, drives the work table **16** inwardly until the operating ram plunger lug **88** engages the stop, as shown in FIG. 8. This arrests the work table **16** in its intermediate, work heating position of FIG. 13. Retraction of the stop **84** permits continued inward driving of the work table **16**, by its operating ram **62**, to the inner extended work bonding position of the table, illustrated in FIGS. 4, 11 and 15.

Associated with the heater blade **30** are means **90** for supporting the blade and driving the latter vertically between its extended position of FIGS, 9, 10, 12 and 13 and its retracted position of FIGS. 3, 4, 11, 14 and 15. The blade driving means **90** comprise a pair of levers **92** which are pivotally supported intermediate their ends on the frame beam **50**, adjacent the ends of this beam. The levers **92** extend generally longitudinally of the beam and project beyond the adjacent ends of the beam, as shown. Pivotally attached intermediate their ends to the outer ends of the levers **92** are connecting links **94**. The upper ends of the connecting links **94** are pivotally attached to the ends of the heater blade **30**. Pivotally attached at their upper ends to the inner ends of the heater blade operating levers **92** are connecting links **96**. The lower end of each connecting link **96** is pivotally attached to the overlapping ends of a pair of connecting links **98** and **100**. Each link **98** extends from its respective connecting link **96** generally longitudinally of and toward the center of the machine frame **12**. The inner end of each link **98** is pivotally connected, by a coupling link **102**, to the underside of the frame beam **50**. The lower end of each connecting link **100** is pivotally attached to the plunger **104** of a blade operating ram **106**. Each ram **106** has a cylinder **108** which is pivotally attached to the machine frame **12**. Extending between the lower end of each connecting link **94** and the common pivot joint of the corresponding connecting links **96, 98, 100** is a tension spring **108** in series with a turnbuckle **110**. The springs **108** are attached to the connecting links **94**. The turnbuckles **110** are connected to the common pivot joints of the corresponding links **96, 98, 100**.

It is evident from the foregoing description and from FIG. 1 that the springs **108** serve to longitudinally tension the heater blade **30**. The turnbuckles **110** are adjustable to vary the tension in the blade. Referring particularly to FIG. 1, it will be observed that downward retraction of the heater blade operating ram plungers **104** in FIG. 1 into their respective ram cylinders **108** elevates the heater blade **30** to its extended position of FIGS. 9, 10, 12 and 13. Upward extension of the ram plungers **104** from their cylinders **108** lowers the heater blade **30** to its retracted position of FIGS. 3, 4, 11, 14 and 15.

The heater blade **30** is electrically heated. To this end, the blade comprises an electrical heating element through which an electrical current is adapted to flow for heating the element. At the end of the blade are electrical terminals **112**. These terminals are electrically connected to the blade heating means **32** which, in this instance, comprises an electrical power source for supplying energizing current to the blade. The manner in which the power

source is controlled will be explained presently in connection with the control system **36**.

As noted earlier, the present plastic welding machine **10** is equipped with work clamping means **28** for clamping the plastic work members or sheets **22**, **24** to the work tables **14**, **16**. These work clamping means comprise a clamping mechanism **114** for the work sheet **22** and the fixed work table **14** and a second clamping mechanism **116** for the work sheet **24** on the movable work table **16**. The work clamping mechanism **114** has a number of fluid pressure actuated rams **118** which are spaced lengthwise of the machine and include cylinders **120**. The upper ends of these cylinders are pivotally attached to a cross beam **122** which extends lengthwise of the welding machine, a distance above the work tables **14**, **16** and directly over the frame beam **50**. Movable in an extending from the lower end of each cylinder **120** is a plunger **124**. The lower ends of the plunger **124** are rigidly secured to a clamp bar **126** which extends the full length of the machine just over the work table **14**, adjacent and parallel to its inner edge **18**. The work clamping mechanism **116** is identical to the work clamping mechanism **114** except that the plungers **124***a* of the rams **114***a* of the clamping mechanism **116** have pivot joints **124***b* which permit the clamping bar **126** of the clamping mechanism **116** to rock back and forth relative to the plungers for reasons to be explained presently. Controls **128** are provided for selectively pressurizing the rams **114**, **116** to extend the clamping bars **126** downwardly into clamping engagement with the work sheets **22**, **24** and raise the clamping bars out of clamping engagement with the work sheets. Pressure fluid is conveyed to and from the rams **114**, **116** through conduits **130** extending through the hollow interior of the upper frame cross member **122**.

Reference is now made to FIG. 16 illustrating the control circuit **36** of the present welding machine. This control circuit has terminals **132** for connection to an electrical power source and leading to the machine through a main switch **134**. Closure of the main switch **134** delivers electrical power to a transformer **136** and to the heater blade energizing unit **32**. Connected to the secondary of the transformer **136** are a pair of main leads **138**, **140**. Connected in electrical parallel within the lead **138** are the normally open contacts **142***a* of a control switch **142** and the normally open contacts **144***a* of a relay **144**. One terminal of the relay coil **144***b* is connected to the normally open sides of the switch contacts **142***a* and the relay contacts **144***a*. The other terminal of the relay coil **144***b* is connected to the main lead **140** through the normally closed contacts **146***a* of a control relay **146**. It is now evident, therefore, that closure of the control switch contacts **142***a* energizes the relay coil **144***b* and this, in turn, results in closing of the relay contacts **144***a* to lock or hold the coil in energized condition. Relay **146** has three sets of normally open contacts, **146***b*, **146***c* and **146***d*. Relay contacts **146***b* and **146***c* will be referred to presently. Relay contacts **146***d* are connected in electrical parallel with the manual switch contacts **142***a* and the relay holding contact **144***a*.

As shown in the upper central portion of FIG. 16, the work table drive ram **62**, the work table limit stop ram **80**, and the heater blade drive rams **106** receive working fluid under pressure from the pressurized fluid supply **148** through a manifold line **150** and solenoid valves **152**, **154** and **156**, respectively. One terminal of each valve **152**, **154** and **156** is directly connected to the main power supply lead **140**. The other terminal of the solenoid valve **152** for the table drive cylinder **62** is connected to the main power lead **138** through the normally open contact **146***b* of the control relay **146**, a set of selector contacts **158***a* of a selector gang switch **158**, and the contacts **160***a*, **160***b* of a timing relay **160**. The timing relay contacts **160***a* are normally closed and the timing relay contacts **160***b* are normally open. The other terminal of the solenoid valve **154** for the work table limit stop positioning ram **80** is connected to the main power lead **138** through a second set of selector contacts **158***b* of the selector gang switch **158**. Finally, the other terminal of the solenoid valve **156** for the heater blade drive rams **106** is connected to the lead **138** through the normally open control relay contacts **146***b* and the selector switch contacts **158***a*. The selector switch **158** has three additional sets of selector switch contacts **158***c*, **158***d* and **158***e*. Indicator lamps **162**, **164** are connected between the main power lead **140** and the selector switch contacts **158***c*, **158***d* as shown. Each of the selector switch contact sets **158***a*, **158***b*, **158***c*, **158***d*, and **158***e* has a rotary contact. These several rotary contacts are ganged on a common shaft such that all of the rotary contacts may be turned from one position to the other in unison. The rotary contacts of the contacts sets **158***a*, **158***b*, **158***d*, and **158***e* are directly tied to the power lead **138**. The rotary contact of the remaining contact set **158***c* is connected, by a jumper **166**, to certain contacts of the adjacent contact set **158***b*, for reasons to be explained presently.

It should be noted here that the work clamping rams **118**, **118***a* of the work clamping means **28** receive working fluid under pressure from the fluid manifold **150** through valves which comprise the clamp control means **128**. Thus, the work clamping rams **118**, **118***a* may be selectively pressurized, by operation of the ram valves **128**, to extend the clamping bars **126** into and retract these bars from clamping engagement with the work sheets **22**, **24** on the work tables **14**, **16**.

The upper right-hand portion of the control system **36** in FIG. 16, which is serviced by the selector gang switch contacts **158***a*, **158***b*, **158***c* and **158***d* is designed to effect the manual setting mode, referred to earlier, of the present plastic welding machine. The remaining, lower right-hand portion of the control system, which is serviced by the remaining selector gang switch contact **158***e*, is designed to effect the automatic welding load or cycle of the machine. This latter portion of the control system includes the control relay **146** and the timing relay **160**. One terminal of each of these relays is directly connected to the main power lead **140**. The remaining terminal of the control relay **146** is connected to the other power lead **138** through the selector switch contacts **158***e*, the normally open contacts **170***a* of a manual control switch **170**, a set of normally open contacts **146***c* of the control relay **146**, a normally closed limit switch **171** for the movable work table **16**, and a set of normally closed contacts **160***c* of the timing relay **160**. The control relay contacts **146***c* and the manual switch contact **170***a* are arranged in electrical parallel, as are the work table limit switch **171** and the timing relay contacts **160***c*. The other terminal of the timing relay **160** is connected to the main power lead **138** through the selector switch contacts **158***e*, the control relay contacts **146***c*, the manual switch contacts **170***a*, a set of normally open contacts **160***d* of the timing relay and a set of normally open contacts **172***a* of a temperature control relay **172**. This temperature control relay includes a set of normally closed contacts **172***b*. One terminal of the temperature control relay **172** is directly connected to the power lead **140**. The other terminal of the relay is connected to the power lead **138** through the selector switch contacts **158***e*. An indicator lamp **174** is connected across the temperature control relay.

Associated with the energizing unit **32** for the heater blade **30** is a current control device **176**, referred to herein as a welder control. This welder control has two input terminals **176***a*, **176***b*. Terminal **176***a* is directly connected to the main power lead **140**. The other input terminal is connected to the other power lead **138** through the normally closed contact **172***b* of the temperature control relay **172**, the control relay contacts **146***c*, the manual switch contacts **170***a*, and the selector switch contacts **158***e*. The welder control **176** has output terminals which

are connected, through leads **178**, to the heater blade energizing unit **32**.

The operation of the present plastic welding machine **10** will now be described in detail by reference to FIG. 16. The machine is conditioned for operation by closing the main switch **134** to deliver energizing current to the heater blade energizing unit **32** and to the primary of the transformer **136**. Initially, the manual control switches **142, 170** will be open and the solenoid valves **152, 154, 156** for the work table drive ram **62**, the work table limit stop positioning ram **80**, and the heater blade drive ram **106** will be deenergized. Under these conditions, the ram **80** is pressurized in a direction to retract the work table limit stop **84** and the ram **62** is pressurized in a direction to drive the work table **16** inwardly to its extended work bonding position of FIGS. 3, 4, 11 and 15. The initial operating step of the machine involves rotation of the selector switch **158** to its number one position, illustrated in FIG. 16, and depression of the manual control switch **142** to momentarily close its contacts **142***a*. Closure of these switch contacts energizes the relay coil **144***b* with resultant closing of the normally open relay holding contacts **144***a* to lock the relay in its energized condition. Closing of the relay holding contacts **144***a* also energizes the selector switch **158**. Under these conditions, the solenoid valve **152** for the work table drive ram **62** is energized through the selector switch contacts **158***a* and the normally closed timing relay contacts **160***a*. The ram **62** is then pressurized in a direction to retract the movable work table **16**. Simultaneously, the solenoid valve **156** for the heater blade operating rams **106** is energized through the selector switch contacts **158***a*. These rams are then pressurized in a direction to elevate the heater blade **30** to its extended work heating position of FIGS. 9 and 10. A thermoplastic work sheet **22** is then placed on top of the fixed work table **14**, and the sheet is moved edgewise toward and into engagement with the heater blade **30**, as shown in FIG. 10. This locates the work sheet in proper welding position on the work table **14**. The rams **118** of the work clamping mechanism **114** are then pressurized in a direction to lower the corresponding work clamping bar **126** into clamping engagement with the work sheet **22** to retain the latter in position on the work table **14**. At this time, the indicator lamp **164** is energized through the selector switch contacts **158***d* to indicate the position of the selector switch in its number one position.

After the work sheet **22** has been firmly clamped to the fixed work table **14**, the selector switch **158** is rotated to its number two position. In this number two position, the selector switch contacts **158***a* are open to deenergize the solenoid valve **152** for the work table drive ram **62** and the solenoid valve **156** for the heater blade operating rams **106**. Simultaneously, the selector switch contacts **158***b* are closed to energize the solenoid valve **154** for the work table stop positioning ram **80**. The ram **80** is then pressurized in a direction to extend the work table positioning stop **84**. Deenergizing of the solvenoid valves **152, 154** results in lowering of the heater blade **30** to its retracted position and inward extension of the work table **16** to its intermediate position of FIG. 11, wherein inward extension of the table is arrested by the currently extended table stop **84**. Rotation of the selector switch contacts **158***c* and **158***d* to their number two positions darkens the indicator lamp **164** and illuminates the indicator lamp **162** to indicate that the selector switch is in its number two position. At this point, the second work sheet **24** is placed on top of the movable work table **16** and is moved edgewise toward the work sheet **22** to butt the confronting edge surfaces **26** of the work sheet. The clamping rams **118***a* for the work clamping mechanism **116** are then pressurized to lower the corresponding clamping bar **126** into clamping engagement with the work sheet **24**, thereby to firmly clamp the latter in position on the work table **16**.

This completes the manual setting mode of the present plastic welding machine and conditions the latter for its automatic welding mode or working cycle. This automatic working cycle of the machine is initiated by rotation of the selector switch **158** to its number three position and depression of the manual control switch **170** to close its normally open contact **170***a*.

Closure of the switch contacts **170***a* energizes the control relay **146** through the work table limit switch **171**. Control relay **146**, when energized, operates to open its normally closed contacts **146***a* and to close its normally open contacts **146***b*, **146***c*, and **146***d*. Opening of the relay contacts **146***a* breaks the holding circuit of the relay **144**, thereby reopening its holding contact **144***a* and interrupting the energizing circuit to the selector switch **158** through the relay **144**. However, closure of the relay contact **146***d* simultaneously completes an energizing circuit to the selector switch and parallel with the now open relay holding contacts **144***a*. Accordingly, the selector switch remains energized. As a consequence, closure of the control relay holding contacts **146***c* in response to energizing the control relay **146** through the manual switch contacts **170***a* locks the control relay in energized condition. Closure of the control relay contacts **146***b* completes an energizing circuit from the power lead **38** to the timing relay contacts **160***a* and **160***b* and parallel with the now open selector switch contacts **158***a*. The work table solenoid **152** and the heater blade solenoid **156** are thereby energized to retract the movable work table **16** and raise the heated blade **30**. The work table limit stop solenoid **154** is energized through the selector switch contacts **158***b* to extend the work table limit stop **84**. Retraction of the work table **16** opens the work table limit switch **171**. However, the control relay **146** remains energized through the normally closed timing relay contacts **160***c*. It should be noted here that rotation of the selector switch **158** to its number three position extinguishes the indicator light **162** and illuminates the indicator light **174** to indicate that the selector switch is presently in its number three position. Referring to the lower portion of FIG. 16, it will be observed that when the selector switch **158** is in its number three position, the welder control **176** is energized through the normally closed contacts **172***b* of the temperature control relay **172**.

It will now be understood that when the present plastic welding machine is conditioned for its automatic working or welding cycle by rotation of the selector switch **158** to its number three position and closing of the manual start switch **170**, the moveable work table **16** is initially retracted and the heater blade **30** is raised to its extended work heating position. Simultaneously, the welder control **176** is energized to activate the heater blade heating means **32** which then heats the blade to proper work heating temperature. The movable work table **16** remains retracted during this heating phase of the machine operation.

Associated with the temperature control relay **172** are thermocouples **180** or other temperature sensors for sensing the temperature of the heater blade **30**. When the blade reaches its proper operating temperature, the temperature control relay **172** is energized to close its normally open contacts **172***a* and open its normally closed contacts **172***b*. Opening of the temperature control relay contacts **172***b* de-energizes the welder control **176** to terminate heating of the blade **30**. Closing of the temperature control relay contacts **172***a*, energizes the timing relay **160**.

Timing relay **160** has two operating phases. The first operating phase occurs instantaneously in response to energizing of the timing relay by closing of the temperature control relay contacts **172***a*, and involves opening of the timing relay contact **160***a* and closing of the timing relay contact **160***b*. Relay contacts **160***d* are holding contacts with the timing relay **160**. Closing of these contacts, therefore, locks the timing relay in its energized condition. Opening of the timing relay contacts **160***a* de-energizes the work table solenoid valve **152** and causes inward extension

of the work table to a position wherein the inner edge of the thermoplastic worksheet **24** on the table engages the sheeted blade **30**. At this point, it is significant to recall that the blade is currently in its upper extending work heating position, wherein the blade engages the inner edge of the thermoplastic worksheet **22** on the fixed work table **14**. The timing relay **160** remains in its first operating phase for a predetermined interval of time, sufficient to cause heating of the inner edge surfaces of the work sheets **22, 24** to the proper tacky state for bonding of the sheets to one another. This time interval is typically on the order of thirty to sixty seconds.

At the end of the interval, the timing relay **160** enters its second operating phase. This second operating of the timing relay involves simultaneous closure of its normally open contact **160***b* and opening of its normally closed contacts **160***c*. Closure of the timing relay contacts **160**b re-energizes the work table solenoid valve **152** to cause outward retraction of the moveable work table **16**. This outward retraction of the moveable work table separates the work sheets **22, 24** to release the blade **30** for downward movement to its retracted position. Opening of the timing relay contacts **160***c* provides a single energizing circuit for the control relay **146** which is through the currently closed work table limit switch **171**. As the currently retracting moveable work table **16** approaches its outer limiting position, it engages and opens this limit switch to de-energize the control relay **146**. The control relay contacts **146***a*, **146***b*, **146***c* and **146***d* then return to their normal positions. In these normal positions, the control relay contacts **146***b* and **146***d* are open, so that the control circuit is restored to its normal de-energized state. This causes de-energizing of the work table solenoid valve **152**, the limit stop solenoid valve **154**, and the heater blade solenoid valve **156**. The heater blade **30** now returns to its lower retracted position, the limit stop **84** returns to its retracted position, and the moveable work table **16** moves inwardly to its fully extended position, wherein the now tacky inner edges of the thermoplastic work sheets **22, 24** are pressed into firm mutual bonding contact to effect butt welding of these work sheets to one another. The work sheets are left in position on the work table until the bond between the sheets is properly cooled. The welded sheets are then removed from the machine to complete one operating cycle.

While the invention has been disclosed in connection with the presently preferred embodiment thereof, various modifications of the invention are possible within the spirit and scope of the following claims.

What is claimed as new in support of Letters Patent is:

1. A machine for thermally butt welding two wide thermoplastic work sheets edge to edge comprising:

a frame,

a pair of coplanar horizontal work tables mounted on said frame for relative edgewise movement toward and away from one another, said tables having adjacent confronting edges and work supporting surfaces,

means for clamping said work sheets to said tables, respectively, with edge surfaces of the sheets disposed in parallel confronting relation along said confronting table edges, said clamping means comprising clamping bars which engage said work sheets closely adjacent and parallel to said edge surfaces and press said work sheets against said tables along the full length of said edge surfaces,

a heater blade mounted on said frame within a plane passing between said confronting table edges generally normal to said table surfaces for movement in said plane between an extended work heating position wherein said blade is located approximately at the level of said table surfaces and a retracted position spaced from said tables,

means for driving said blade between its extended and retracted positions,

means for heating said blade,

means for driving said tables in relative edgewise movement between retracted positions wherein said edge surfaces of the work members when clamped to said tables are spaced a substantial distance apart and extended work bonding positions wherein said edge surfaces of the work members are pressed firmly together, and through intermediate work heating positions when said edge surfaces of the work members are slightly spaced and disposed for contact with opposite sides of said blade when said blade occupies its extended work heating position, and

operating means including means responsive to the temperature of said blade for operating said blade heating means, said blade driving means, and said table driving means in timed relation in such a way as to cause said machine to proceed through an automatic work cycle involving initial relative retraction of said tables, heating of said blade to a predetermined temperature, extension of said blade to its work heating position, relative extension of said work tables to their intermediate work heating position in response to heating of said blade to a predetermined tempearture to bring said edge surfaces of the work members into contact with said blade for heating of said edge surfaces to a tacky state, momentary relative retraction of said tables, retraction of said blade, and reextension of said tables to work bonding position to bring the heated tacky edge surfaces of said work members into firm bonding contact.

2. A machine according to claim **1** wherein said operating means comprises:

timing means activated in response to relative extension of said tables to intermediate work heating position to effect retention of said tables in said intermediate position for a predetermined interval of time and then momentary relative retraction of said tables.

3. A machine according to claim **1** wherein said operating means comprises:

timing means activated in response to relative extension of said tables to intermediate work heating position to effect retention of said tables in said intermediate position for a predetermined interval of time and then momentary relative retraction of said tables, and

limit means operable in response to relative extension of said work tables to work bonding position for restoring said operating means to a normal state, wherein said operating means are conditioned for the next operating cycle of said machine.

4. A machine according to claim **1** wherein:

one of said tables is fixed and the other table is movable toward and away from the fixed table, and

said table drive means comprise a pair of levers extending lengthwise of the movable table between the center and ends of the movable table, pivot means pivotally connecting the other ends of said levers to said frame, means connecting said levers and movable table adjacent said lever pivot means, whereby pivoting of said levers extends and retracts said movable table, and a fluid pressure ram connected between said frame and the inner ends of said levers.

5. A machine for thermally butt welding two wide thermoplastic work sheets edge to edge comprising:

a frame,

a pair of coplanar tables mounted on said frame and having confronting edges and work supporting surfaces,

means rigidly securing one of said tables to said frame,

means supporting the other table on said frame for edgewise movement toward and away from said fixed table,

a pair of levers extending lengthwise of said movable

table between the center and ends of said movable table, pivot means attaching the outer ends of said lever to said frame,

means connecting said levers and movable table adjacent said pivot means, whereby rotation of said levers about their respective pivot means moves said movable table edgewise toward and away from said fixed table, and

a fluid pressure actuated ram connected between the inner ends of said levers and said frame for rotating said levers to drive said movable table toward and away from said fixed table.

6. A machine for thermally butt welding two wide thermoplastic work sheets edge to edge comprising:

a frame,

a pair of coplanar work tables mounted on said frame for relative edgewise movement toward and away from one another, said tables having confronting edges and work supporting surfaces, one table being fixed to said frame and the other table being movable relative to the fixed table,

fluid pressure actuated ram means for effecting relative edgewise movement of said tables toward one another to fully extended positions, wherein said table edges are disposed in close proximity comprising a fluid pressure actuated ram between the ends of said movable table, levers extending lengthwise of said movable table between said ram and the ends of said movable table, pivot means pivotally attaching the outer ends of said levers to said frame, means pivotally joining said levers and movable table adjacent said pivot means whereby rotation of said levers about said pivot means drives said movable table edgewise toward and away from said fixed table, and means operatively connecting said ram to

the inner ends of said levers whereby extension and retraction of said ram rotates levers to extend and retract said movable table, and

a retractible limit stop means which is extendable to limit inward extension of said movable table to an intermediate partially extended position, wherein said confronting table edges are spaced a predetermined distance and retractible to permit full inward extension of said movable table toward said fixed table.

7. A machine according to claim **6** wherein:

said limit stop is mounted on said frame for extension into the path of extension of said ram.

References Cited

UNITED STATES PATENTS

2,272,881	2/1942	Stevens	156—366
2,384,014	9/1945	Cutter	156—366
3,100,731	8/1963	Brey	156—502
2,928,926	3/1960	Winz	156—367X
3,186,891	6/1965	Gelling et al.	156—366
3,282,766	11/1966	Wright	156—304X
3,299,251	1/1967	Zelnick	156—366X
3,325,328	6/1967	Henley	156—502X

FOREIGN PATENTS

626,520	8/1961	Canada	156—502

BENJAMIN A. BORCHELT, Primary Examiner

G. E. MONTONE, Assistant Examiner

U.S. Cl. X.R.

156—362, 359, 367, 502, 544